Nuclear INFORMATION

Greater St. Louis Citizens' COMMITTEE FOR NUCLEAR INFORMATION

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RADIATION - HOW MUCH IS TOO MUCH?

Radiation is one of the facts of modern life. Atomic power, the fallout from weapons tests, the use of radiation in medical diagnosis and treatment as well as in industrial operations, all involve risks that we can't escape altogether. So the question becomes steadily more acute: how much radiation – if any – is safe and will produce no harmful effects in an exposed individual? This month *Nuclear Information* takes up two aspects of this important problem. The first column on this page deals with the considerations that enter into the setting of safe or proper limits of radiation exposure. Evidently this matter has now become a social rather than a scientific problem. The situation is like the one that existed in the last century, when important discoveries about the infectious nature of many diseases led to a demand for laws to protect the public health from sources of disease. In the first few years of this nuclear age we are just beginning to learn how to set up rules that can protect us from the hazards of radiation. The second column summarizes a new study of the occurrence of leukemia, a form of blood cancer, among the survivors of the atomic bombing of Hiroshima. If there were any lingering doubts about the ability of radiation to cause leukemia, this study will silence them. The disease has become far more prevalent among Hiroshimans than among other Japanese, and susceptibility has proved proportional to the amount of radiation received.

Is There a Safe Limit?

Answering the question, "How much radiation is safe?", is now the job of the Federal Council on Radiation, which President Eisenhower created last August 14. This Council is composed of the Secretary of Health, Education and Welfare (he is the chairman), the Secretaries of Defense, Labor, and Commerce, and the Chairman of the Atomic Energy Commission. Charged with the responsibility for setting standards that will protect the public from excessive radiation, the Council will have at its disposal a newly strengthened radiation protection program in the Department of Health and Welfare, as well as the government's vast scientific resources.

It's Not a Simple Question

Despite all this help, the Council has a tough job on its hands. Let's look at some of the difficulties it will have to face:

- There just isn't enough scientific information about the effects of small amounts of radiation on people.
- The maximum permissible level of radiation most recently recommended for the general public by the group of radiation experts which has been setting these standards for the last 30 years – the International Commission on Radiological Protection (ICRP) – has not been accepted by its U.S. subdivision, the National Committee on Radiological Protection (NCRP).
- The maximum permissible level of radiation has been redefined (by ICRP and NCRP) in such a way that, in the words of one radiation expert, it now ". . . depends to a large extent upon a philosophy of risk, morality and good judgment."
- While the question is debated, radiation levels in many foods – especially those due to strontium 90 – continue to rise, and in some instances (milk in St. Louis in May 1959 and the 1958 wheat crop) have exceeded the permissible level set by the last report of the ICRP. The permissible level chosen by the Federal Radiation Council

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Leukemia and the Atom Bomb

On that August day in 1945 when the first atomic bomb exploded, the city of Hiroshima became a gigantic laboratory. More than 300,000 people were about their business that morning, indoors and out, when the most terrible weapon ever devised burst in their midst. Thousands died at once, and more thousands followed them in the ensuing days and weeks. Those who survived became the unintended guinea pigs of an experiment that could determine – among other things – whether the radiation from a single nuclear explosion can lead to leukemia. The grim results of that "experiment" will be published soon in a report entitled "Leukemia in Hiroshima Atomic Bomb Survivors." This report written by Dr. Robert Heysell and 6 collaborators covers work done by a group of U. S. and Japanese medical men in Hiroshima between 1950 and 1958. The study was carried out under the auspices of the Atomic Bomb Casualty Commission, an agency of the U. S. National Academy of Sciences.

Collecting the Facts

How do you decide if the bomb really caused leukemia? There are a lot of things you have to know: How many people were in the city at the time of the explosion? How many were within any given distance from the bomb site? How much radiation did people receive at various distances? How many of the exposed persons have developed a disease clearly recognizable as leukemia? How many cases of the same disease would occur among an equal number of people who had not suffered from radiation? Are the Hiroshima survivors a representative population, including about the usual number of old and young, males and females? To all these pertinent questions Dr. Heysell and his team supplied careful answers.

Radiation Causes Leukemia

To determine whether leukemia actually results from radiation, Dr. Heysell's group determined how many people were located at distances from 1000 to 2000 meters (5/8 to

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Is There a Safe Limit? *(Continued from page one)*

will determine whether anything will be done to reduce the rising level of radiation in our diet.

The problem of protecting life from radiation is as old as radiation itself. Announcement of the discovery of X-rays by Roentgen was made in Germany on December 28, 1895. Within a month a vacuum tube manufacturer in Chicago went to his doctor with skin inflammation due to X-rays. In March 1896, Thomas Edison reported that his eyes became sore after he used an X-ray machine. In the next few years there were so many cases of X-ray damage that the question of how much was "safe" became a matter of wide concern.

By 1915 the British Roentgen Society recommended protective measures to physicians and others who used X-rays. Ever since, radiologists have taken an increasing interest in the problem.

The Problem Develops

At first the main problem was to avoid burns and other immediate damage from intense radiation. But as time went on radiologists became more aware of the effects of long continued slight radiation received by operators of X-ray machines from stray "leaks." They also learned – through tragic experience – that excessive exposure to radiation may cause cancer.

In 1928 radiologists set up an international committee to deal with the radiation problem, and this group became, in time, ICRP. This group, though self-constituted and without official status in any government, has in the past 30 years become the guiding authority for policies on permissible doses of radiation.

Between 1928 and 1954, the ICRP published a series of important reports. In preparing these reports the Commission examined new evidence concerning the effects of very low radiation doses. On the basis of this evidence, they attempted to set the maximum amount of radiation that the body can stand without harm. As knowledge of radiation effects improved, the permissible dose was reduced; by 1956 the permissible level of radiation was lowered to one-tenth of the 1936 level.

1954 Definition of Permissible Level

What does the "permissible level" of radiation mean? The 1954 ICRP report gives this definition. "Permissible dose is a dose of ionizing radiation that, in the light of present knowledge, is not expected to cause appreciable bodily injury to a person at any time during his lifetime. As used here 'appreciable bodily injury' means any bodily injury or effect that a person would regard as being objectionable and/or competent medical authorities would regard as being deleterious to the health and well-being of the individual."

Such a definition implies that there is some small amount of radiation that causes no "appreciable bodily injury" and is therefore tolerable. In 1954, and to a degree even today, there was some theoretical justification for this attitude. Studies of certain radiation effects, such as production of cancers, seemed to show that very low levels of radiation failed to increase the incidence of disease. Proof that there is some low level of radiation that does not cause cancer is difficult to obtain. Even the most recent study at Hiroshima leaves us in doubt on this point.

Genes are Never "Safe"

But the effects of radiation on inheritance are a different matter. In 1927 and 1928 two geneticists, H. J. Muller in New York and L. J. Stadler in Missouri, showed that mutations are found with great frequency in the offspring of X-ray treated animals and plants. Further experiments showed that there was no "safe limit" for this effect; any amount of radiation, however small, produced a proportional increase in the number of mutations. Thus even the smallest amounts of radiation we are exposed to may damage our genes and consequently afflict our children and our children's children.

The present scientific situation may be summarized as follows: we are sure that even very small amounts of radiation can cause genetic mutations; this may also be true of cancer, although we cannot yet be sure. In these circumstances, it no longer makes sense to try to define some radiation level below which no physical harm occurs. Between 1954 and 1958 the ICRP took stock of the changing knowledge about radiation effects, and in its report dated September 9, 1958, made important revisions in its earlier recommendations on the permissible dose of radiation.

ICRP Changes its Stand

First, the Commission decided that its 1954 recommendations were too liberal, and that "stricter recommendations were needed." The Commission also took note of increasing evidence that non-genetic radiation effects occur at very low doses. The 1958 report states "The most conservative approach would be to assume that there is no threshold (i.e., no minimum safe dose) and no recovery (i.e., from very small radiation doses), in which case even low accumulated doses would induce leukemia in some susceptible individuals, and the incidence might be proportional to the accumulated dose. The same situation exists with respect to the induction of bone tumors by bone-seeking radioactive substances" (such as strontium 90).

So, between 1954 and 1958 the ICRP seems to have abandoned the view that there is some harmless level that might serve as a guide for establishing the permissible radiation dose, and adopted instead the principle that any amount of radiation may cause harm.

If any amount of radiation – however small – may cause some medical damage, how can we determine what radiation level is "permissible"? If we were sure that very small amounts of radiation cause no bodily harm, then the permissible level could be set by finding out, from medical studies, where the boundary is between harmless and harmful radiation. But if we proceed on the view that any amount of radiation is likely to do some damage, then we need a new definition of the permissible dose. The 1958 ICRP report supplies this new definition:

Permissible Dose is Redefined

"Any departure from the environmental conditions in which man has evolved may entail a risk of deleterious effects. It is therefore assumed that long continued exposure to ionizing radiation additional to that due to natural radiation involves some risk. However, man cannot entirely

dispense with the use of ionizing radiations, and therefore the problem in practice is to limit the radiation dose to that which involves a risk that is not unacceptable to the individual and to the population at large. This is called a 'permissible dose.'

"The permissible dose for an individual is that dose, accumulated over a long period of time or resulting from a single exposure, which, in the light of present knowledge, carries a negligible probability of severe somatic or genetic injuries; furthermore, it is such a dose that any effects that ensue more frequently are limited to those of a minor nature that would not be considered unacceptable by the exposed individual and by competent medical authorities."

How Much is Acceptable?

So we find that the new definition of a permissible radiation dose rests on the idea of its acceptability by either the individual concerned, the population at large, or competent medical authority. How, then, do we discover what risk of damage from radiation is "acceptable"?

With respect to the population the 1958 ICRP report introduces an idea not found in earlier reports: that the permissible dose should represent a balance between the hazard from radiation and the social benefits expected from its use. In the words of the ICRP report:

"Proper planning for nuclear power programs and other peaceful uses of atomic energy on a large scale requires a limitation of the exposure of whole populations, partly by limiting the individual doses and partly by limiting the number of persons exposed.

"This limitation necessarily involves a compromise between deleterious effects and social benefits . . . The Commission is aware of the fact that a proper balance between risks and benefits cannot yet be made, since it requires a more quantitative appraisal of the probable biological damage and the probable benefits than is presently possible. Furthermore, it must be realized that the factors influencing the balancing of risks and benefits will vary from country to country and that the final decision rests with each country."

Social Benefits Enter the Picture

According to this view, the maximum permissible dose for the population is to be determined by balancing the medical risk against the "social benefits" of the radiation-producing operation. The ICRP expects each country to strike its own balance. Defined in this way, the maximum permissible dose no longer rests on scientific evidence alone.

All this has been stated explicitly in a recent article by Dr. Walter D. Claus, of the Atomic Energy Commission and Mr. Lauriston S. Taylor, Chairman of the National Committee on Radiological Protection ("Radiation Biology and Medicine" ed. by W. D. Claus, Addison-Wesley, 1958):

"The 'maximum permissible dose rate' represents an estimate of how much we can afford to risk in terms of potential biological damage, for the benefits which we can obtain from X-rays and gamma rays and from the sources which produce these rays. This concept of 'acceptable risk' is the basis of all estimates of permissible dose. It is perhaps startling to admit that the establishment of permissible levels of radiation exposure today is not basically a scientific problem. The recommendation of permissible exposures depends to a large extent upon a philosophy of risk, morality and good judgement."

How the Permissible Dose is Set Now

The 1958 ICRP report recognizes that no nation is prepared to make the momentous moral decisions involved in balancing atomic risks and benefits. It therefore recommends, in the interim, maximum permissible radiation doses for the general population. This permissible dose is set at 1/30 of the level recommended for atomic workers who are exposed to radiation under occupational conditions. Since in the previous (1954) report, population levels had been set at 1/10 of the occupational levels, this action in effect reduced the recommended population levels. In the case of strontium 90, the recommended maximum permissible concentration was reduced from 80 Sr units to 33. (See *Nuclear Information* for April 1959).

When the 1954 ICRP report was published it was promptly adopted by the NCRP in the United States. However, in the year following the appearance of the 1958 ICRP report, the NCRP has failed to act, and the old Sr-90 maximum permissible concentration of 80 is still the official guide in the United States.

What's to be Done?

This is the difficult situation that faces the Federal Radiation Council, as it considers the establishment of safety standards for radiation exposure. How will the Council establish standards for the population generally? Will it use the old-fashioned standard of an amount of radiation that will result in bodily injury? Will it adopt the new approach of balancing risks and benefits? Will it agree with the ICRP that no data are as yet available for making such a balance, and be guided by the newly recommended permissible levels?

Whatever decision the Council makes will not end there. If it adopts the new ICRP guidelines, health agencies will be faced with the job of deciding what to do about those foods which in some places exceed the new limits.

If the Federal Radiation Council decides that the permissible levels should represent a balance of risk and benefit – who will decide what the benefits are? What scales will weigh the risks against the benefits? Who will decide when they are in balance?

The answers given to these questions will go a long way to determining how we will live in the nuclear age.

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1-1/4 miles) from the point of the explosion. It seems that 1282 of the survivors had been within 5/8 of a mile. Of this number, 15 came down with leukemia between 1950 and 1957. Does that mean anything? It does when you learn that in the Japanese population at large, only two cases of leukemia are expected to occur among *10,000* people in an 8-year period. By contrast, 15 cases among 1282 translates into a rate of 146 cases per 10,000.

For the next distance, 5/8 up to almost a mile, the results are also striking. 10,577 persons had been within this distance, and 32 cases of the disease appeared among them during the period of the survey. In the area from about 1 to 1-1/4 miles, there were 9 cases among 17,654 people – still well above the normal "spontaneous" rate. Only beyond a mile and a quarter did the rate fall to the level found among unexposed Japanese.

These facts leave no doubt about the central issue – the radiation from a single bomb blast does cause leukemia.

More Radiation Means More Leukemia

The facts cited show that the people closest to the explosion were most apt to develop leukemia. As a matter of fact, those who had suffered from radiation sickness at the beginning seemed most susceptible to the blood disease. Does this mean that the likelihood of developing leukemia depends on the amount of radiation received? The Heysell group answered this question by determining how many cases of the disease appeared among about 15,000 people for whom the amount of radiation received (the "dose") could be determined. For doses from 77 REP (about a mile from the site) to 2620 REP (less than ½ mile), the number of cases went up in proportion to the size of the dose. Evidently, more radiation = more leukemia. (REP, which stands for "roentgen equivalent, physical," is a unit of radiation exposure).

Is there a "Safe" Level of Radiation?

Is there some low level below which radiation does not cause leukemia? The number of people who received low doses was not great enough to allow this question to be answered conclusively. Among 4815 persons who had received 19 to 34 REP, only one case of leukemia would normally be expected in 8 years. If only one case is expected, there is practically no chance of detecting any small effect a low dose of radiation might have had. Actually there were no cases of leukemia at all among this group of 4815 people.

Who is Most Likely to get Leukemia?

Are youngsters more likely to be affected by radiation than older people? Is one sex more susceptible than the other? To find out, the Heysell team made separate determinations of the number of cases of leukemia in the two sexes and in different age groups. But this process made the numbers in each category so small that chance variations could confuse the issue. The figures suggest that young people may be more easily affected than the middle aged, and men more than women, but it's only a suggestion.

Does Radiation Speed Up the Onset of Leukemia?

Some authorities feel that radiation will hasten the onset of leukemia in those who are somehow "fated" to get it, for genetic or other reasons, but that it does cause the disease in those who are not predisposed to it. Heysell's group has found that the people who were within about a mile of the explosion center produced within 7 years three times as many cases of the disease as they would normally have developed in their whole lifetimes. So it seems that enough radiation can bring you down with leukemia, even though it's not "in the cards" for you.

It was a Small Bomb.

In absolute terms, the number of Hiroshimans who have succumbed to leukemia is not very large. Among 30,000 people who were within the fatal mile and a quarter and survived the blast, 46 developed the disease during the 8 years of the study. If a city were hit with a modern H-bomb – which is a thousand times more powerful than the Hiroshima bomb – among those who survived, leukemia would be a frequent visitor.

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